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*The University of Minnesota  
Agricultural Experiment Station*

*Factors Determining the Price of  
Potatoes in St. Paul and  
Minneapolis*

*By Holbrook Working  
Division of Agricultural Economics*



UNIVERSITY FARM, ST. PAUL



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# FACTORS DETERMINING THE PRICE OF POTATOES IN ST. PAUL AND MINNEAPOLIS

By HOLBROOK WORKING

## FOREWORD

Most of the readers of this bulletin will find in it certain sections in which they are more especially interested than in others. Growers of potatoes and dealers will find the latter part of the bulletin, beginning with the section on "Use of the Price-Forecasting Formula" (p. 27) of most immediate practical value. The sections on "Description of the Market" and "Considerations Influencing Dealers" (p. 4-8) will be found of almost equal practical value. Growers and dealers who wish to get a better understanding of the fundamental forces which influence price will find it profitable to read the two sections on the various factors which do and do not measurably influence price (p. 15-27).

Economists will be especially interested in the first four sections following the "Summary" (p. 4-15), and in the discussion of the factors which do and do not measurably influence price. Those who wish to study the basis for the results with special care will make use also of the section on "Source of Price Statistics" (p. 10-15).

Most of the methods used in the study are familiar to those who have followed recent developments in the use of partial correlation for the study of time series, as developed chiefly by Professors Warren M. Persons, H. L. Moore, and G. Udney Yule. In some points the methods used by these investigators have been further developed or supplemented by original methods. A technical discussion of the methods used will be published in a later bulletin designed for the use of investigators. Pending its appearance, the writer will be glad to make any necessary explanations for the benefit of any one who may wish to make a similar study for another market.<sup>1</sup>

## SUMMARY

An extended study of the price of potatoes in Minneapolis and St. Paul appears to have resulted in the discovery of all the important fundamental factors determining the price of potatoes in these cities, and the extent to which each of these factors except one influences price. The exact effect of one factor, loss in storage, can not be determined at present, because accurate data on the amount of loss in different years are not available.

<sup>1</sup> Cf. *Infra*, p. 37.

The fundamental factors which influence the price of potatoes to a measurable extent are:

1. Production of potatoes in the entire United States.
2. Loss in storage.
3. Changes in the general price level.
4. A steady and uniform annual increase in the demand for potatoes.
5. Failure of the production of potatoes to increase as rapidly as the demand is increasing.

The following factors which are sometimes thought to exercise a fundamental influence on the price of potatoes have been found to have no measurable effect:

1. Production in the states adjacent to the market (except as it is part of the total United States production).
2. Imports and exports.
3. General business conditions (except to the extent to which they are reflected in the general price level).

A formula has been prepared for use in estimating the price of potatoes in Minneapolis and St. Paul from the available statistics. Ordinarily only two of the five factors influencing price vary much from year to year, namely, production and loss in storage. A third factor, general price level, usually does not change much from one year to the next, tho its fluctuations in recent years have been great. Of the three factors which are the most important of the five, only two can be included in the formula directly, as there are no statistics on losses in storage. Even the production figures are unsatisfactory because inaccuracies in the estimates of changes in acreage of potatoes are so great that it has been found more satisfactory to assume a uniform annual increase instead of using the acreage figures issued by the United States Department of Agriculture.

Despite these limitations, it has been found possible to estimate the average annual price of potatoes in the Twin Cities with an average error of about 9.5 per cent—slightly less than 5 cents a bushel on the basis of the ten-year pre-war average price. Farmers and dealers making use of the formula can remove much of the possibility of error in the estimate by estimating the probable loss in storage and making the necessary allowance in the formula.

## DESCRIPTION OF THE MARKET

In order to understand the significance of the various price movements and the forces which cause the movements, it is necessary to know something of the market itself and the way in which it works. The price of potatoes at any time and place is the direct result of the opinions of the men who are buying and selling at that place. To

understand price movements it is necessary to know what factors influence the opinions of these men.

The dealers in Minneapolis and St. Paul may be considered members of a single potato market. These dealers buy from farmers, coöperative associations, or local dealers at country points in the potato producing sections and either ship directly or put the potatoes in storage in their local warehouses. The practice of the Minnesota Potato Exchange differs from the other agencies chiefly in the fact that the Exchange never actually owns the potatoes which it sells. In many respects it may be considered as filling the position of a commission merchant, since the farmers decide when the potatoes shall be sold.

The potatoes which pass through the hands of dealers in Minneapolis and St. Paul are almost entirely sold to wholesalers in cities to the south and east. Roughly speaking, potatoes sold out of the Twin Cities are consumed chiefly in the middle west.<sup>2</sup> Numerous shipments are made into states much farther distant, especially to the south, while occasional cars are sold even in New England and other Atlantic Coast states and in California. Variations in the potato crop in the different sections from year to year cause a wide variation in the amount of potatoes which can be sold in any state. One of the best recognized cases of this sort is that of Iowa. Iowa raises a sufficient acreage of potatoes to supply practically all local needs in a good year, but when the Iowa crop is short, large quantities of Minnesota potatoes are shipped in.

Of course, a large proportion of the potatoes sold from the Twin Cities is intended for seed. Seed stock goes very largely to the southern states, altho there is also a demand for northern seed in middle latitude states. The price of seed stock is determined by forces differing somewhat from those governing the price of eating stock and will be considered only briefly in this bulletin.

## CONSIDERATIONS INFLUENCING DEALERS

The question of the factors influencing the price of potatoes in the Twin Cities is best approached by looking at it first from the point of view of the dealer in the Twin Cities. What determines the price for which he will sell potatoes?

First consider a common, but mistaken, answer. It is frequently said that a dealer will be willing to sell for a price that will give him a reasonable margin over what he paid. This is not the case. The good business man will sell potatoes for the best price he can get,

<sup>2</sup> The principal states to which shipments of table stock are made, according to the reports of dealers, are Iowa, Illinois, Kansas, Missouri, Indiana, and Ohio.



irrespective of what he has paid for them. Sometimes it happens that a dealer makes much more than an ordinary profit on a car of potatoes, and again it sometimes happens that a dealer loses heavily on a car of potatoes. The truth is that the price a dealer will pay for potatoes depends upon what he thinks he can sell them for, always remembering, of course, that this is a maximum price; the dealer will gladly buy the potatoes for less if he can.

In the effort to get the highest possible price, dealers watch the markets carefully in order to make their sales to the best advantage. The market news service of the United States Department of Agriculture has done much to make it easy for dealers to keep informed regarding prices and supplies in other markets. Prospective buyers watch the markets in a similar manner in order to buy to the best advantage. The result is that prices in all the markets of the country are very closely related, the price differences being based on the expenses of moving the potatoes along the lines on which it is found most profitable to move them.

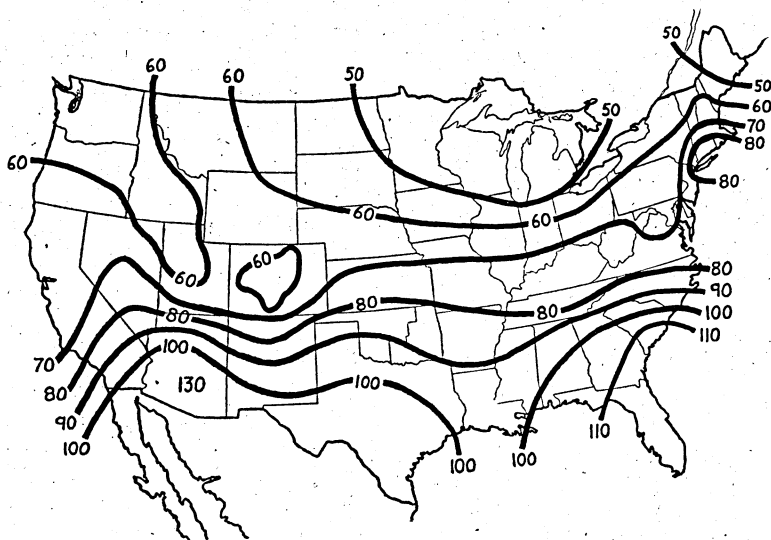


Fig. 1. Isotims (Lines of Equal Price) of Ten-Year Average Farm Price of Potatoes, December 1, 1906-1915 (cents per bushel)

The map shows clearly the relatively low prices in the surplus-producing regions, increasing in all directions along the lines on which the potatoes are shipped.

The effect of this adjustment is shown in Figure 1, which is an isotimic map<sup>3</sup> of the average farm price on December 1 for the ten-year period before the war. The map shows variations in prices from

<sup>3</sup> That is, a map showing lines of equal price. This type of map promises to be quite useful in showing the geography of prices. The name suggested is from the Greek *ίσος*, *equal*, *τιμή*, *price*. Strict adherence to the Greek would give the adjective *isotimetic*, but in adapting it to English use it is better abbreviated to *isotimic*, as the relation to the noun *isotim* is clearer in this form.



one section to another as an isothermal map shows variations in temperatures. The effect of each surplus-producing region upon the price system is clearly apparent on the map. The largest single surplus-producing area is that including Minnesota, Wisconsin, and Michigan. In these states the price is low, increasing in all directions along the lines the potatoes follow to the regions where they are ultimately consumed. The price system in any one year will usually be quite similar to the one shown on the map, but will vary somewhat from this ten-year average, as the production in certain areas is above or below the average.

TABLE I  
TEN-YEAR AVERAGE DECEMBER 1 FARM PRICE OF POTATOES, 1906-15, BY STATES\*

State	Price per Bu.	State	Price per Bu.	State	Price per Bu.
	Cents		Cents		Cents
Maine .....	54	Florida .....	116	Mississippi .....	95
New Hampshire..	70	Ohio .....	64	Louisiana .....	91
Vermont .....	60	Indiana .....	64	Texas .....	106
Massachusetts ...	80	Illinois .....	70	Oklahoma .....	97
Rhode Island....	84	Michigan .....	45	Arkansas .....	90
Connecticut .....	82	Wisconsin .....	44	Montana .....	61
New York .....	63	Minnesota .....	44	Wyoming .....	74
New Jersey .....	76	Iowa .....	59	Colorado .....	59
Pennsylvania ...	68	Missouri .....	74	New Mexico.....	98
Delaware .....	72	North Dakota ...	52	Arizona .....	130
Maryland .....	65	South Dakota ...	54	Utah .....	59
Virginia .....	71	Nebraska .....	64	Nevada .....	76
West Virginia...	76	Kansas .....	83	Idaho .....	51
North Carolina ..	81	Kentucky .....	76	Washington ....	56
South Carolina ..	115	Tennessee .....	77	Oregon .....	59
Georgia .....	103	Alabama .....	98	California .....	77

\* Data from Yearbook of United States Department of Agriculture, 1915, p. 458. These data, together with maps of the production areas and of the railroads of the country, form the basis for drawing the isotims in Figure 1.

The close interrelation of prices all over the United States makes it apparent that the price for which any dealer can sell potatoes depends chiefly on factors over which he individually has no control. Indeed, if dealers did not store potatoes, but merely formed a link in a chain passing the potatoes as rapidly as possible from producer to consumer, dealers would have practically nothing to do with determining the price of potatoes. Price would be determined directly by the willingness of the farmers to sell at the prices consumers were willing to pay.

In actual fact, many dealers are accustomed to store large quantities of potatoes whenever they think they can make money thereby. The dealer who has facilities for storing potatoes considers not only the prices which he can get now for potatoes in the various places where he can sell, but also the prices which he expects to be able to get in the future.

Because of this opportunity to profit by storing, most dealers are always on the alert to judge when prices are "too high" or "too low." If they think prices are lower than is justified by fundamental conditions of demand and supply they buy for storage, expecting prices to rise. Or if they think prices are higher than is justified by fundamental conditions, they work off any stocks they may have on hand and resell every lot as quickly as possible.

The dealer who lays in stocks of potatoes when he thinks prices are too low and sells when he thinks prices are too high and who is skilful enough to judge the market correctly most of the time, is assured good profits. Similarly, the farmer who uses good judgment in deciding when to sell his potatoes will get a better price than will the farmer who uses poor judgment. In fact, it may be laid down as a general rule that everybody engaged in buying and selling potatoes is concerned ultimately with judging what the price "ought" to be—that is, in determining what price is justified by fundamental demand and supply conditions. This is true of dealers, of farmers, and even of some consumers. The only exceptions occur in the cases of those dealers and consumers who make a practice of buying only for immediate needs. Such purchasers keep very small supplies on hand and need to study the market only for the purpose of knowing where to buy to the best advantage, and, perhaps, of postponing purchases a few days at most, in case a temporary shortage develops.

It is apparent, therefore, that the chief force determining the price of potatoes at a particular time is the opinion of buyers and sellers (including chiefly dealers and farmers) as to what price is justified by fundamental conditions of demand and supply. Every farmer and every dealer who plans to lay in stocks of potatoes at favorable times needs to understand these fundamental forces of demand and supply. It is only by understanding them that either farmer or dealer can correctly judge when prices are too low or too high. The remainder of this bulletin is devoted to explaining the operation of the fundamental forces which have been found to be important in determining the price of potatoes in the Twin Cities and to showing how the facts should be interpreted in order to be of use to farmers and to dealers.

### BASIS FOR DETERMINING FUNDAMENTAL FACTORS AFFECTING PRICE

Before proceeding further, a word must be said regarding the method by which certain factors have been found to be important in determining prices, and by which the exact effect of each factor has been measured.

Buyers and sellers of potatoes are frequently mistaken as to the price justified by fundamental economic conditions. If such an error

is general in the fall, it may happen, for example, that the price which results is too high. If the price is too high in the early part of the season, potatoes will not be consumed fast enough to dispose of the supply available. Farmers and dealers will then find that not all of the stocks on hand can be sold at existing prices. Since potatoes can not be carried over from one year to the next, the price, under such conditions as have been mentioned, must be lowered enough to permit the supply to be disposed of before the end of the season. A properly adjusted price would remain the same throughout the season, except for a gradual advance to cover cost of storage, and would maintain a fairly uniform consumption throughout the season. But since an abnormally high price early in the season causes small consumption, it must be compensated by an abnormally low price during the remainder of the season, or not all the crop can be sold.

Similarly, if the price is abnormally low early in the season, the supply will be exhausted too rapidly and those who still have potatoes will find that they can get abnormally high prices for them during the remainder of the season. The result is that, altho the price at any one time may differ from the normal price justified by demand-and-supply conditions, the average price for a season will come very close to the normal.

This fact makes it possible to consider the actual average price for a season as the price which was justified by the fundamental demand and supply conditions existing during the season. The price at the beginning of a season is the result of the opinions of buyers and sellers as to what price the fundamental conditions justify. If those opinions are mistaken, the error must be compensated later. The resulting average price may be considered as the effect of actual conditions rather than of mere opinions regarding conditions.

Thus far it has been assumed that a price, for example, 10 per cent too low during the first half of the season, will be compensated accurately by a price 10 per cent too high during the latter half of the season. The curved line in Figure 2, p. 16 (to be explained more fully in a later section), shows the relation between production and price. It may be looked upon also as showing the relation between price and consumption. If the curve be studied from this point of view, it will be seen that a decrease of 10 per cent in the price will increase consumption more than an increase of 10 per cent will diminish it. As a result, it appears that a low price during part of a season will be compensated only by a disproportionally high price during the remainder of the season. The average thus obtained for an entire season will be somewhat higher than the average which would have resulted had a proper price been established at the beginning of the season.

This difficulty is eliminated by taking the harmonic mean of the monthly prices instead of the ordinary arithmetic mean or "average."<sup>4</sup> The harmonic mean is a well recognized type of average used in statistical work. It is equivalent to calculating the average number of bushels sold for a dollar and converting this average into price per bushel. This will not ordinarily give the same result as calculating the average price per bushel in the usual way.

### SOURCE OF PRICE STATISTICS

Since the spring of 1917, the local office of the Bureau of Agricultural Economics of the United States Department of Agriculture has been collecting daily information on the price of potatoes in Minneapolis and St. Paul. For the period before the spring of 1917 the only published source of such information is the reports in various daily and weekly papers.

Papers which have to depend upon their own resources to obtain market-price information frequently do not exercise sufficient care in collecting it. Usually they depend upon the opinions of a single dealer, who may be mistaken in his opinion of the ruling price or may even have reasons for somewhat misrepresenting the facts. The task of collecting really accurate information is frequently too difficult and expensive for the ordinary paper to undertake.

Because of the doubtful accuracy of the price data to be obtained from the files of daily and weekly papers, such data have been obtained from the original records of dealers themselves. Four dealers in Minneapolis and St. Paul were found to have records extending as far back as 1912 or earlier. Of these four, three had records going

<sup>4</sup> If the demand curve were a straight line, a decrease in price would raise consumption by the same amount that an equal increase in price would diminish consumption. The arithmetic average under these conditions would give a price which, if maintained throughout the season, would result in the same consumption as occurred under the varying prices actually existing. The actual demand curve is not a straight line, but if production (or demand) be plotted against the reciprocal of price, the demand curve becomes a straight line. The reciprocals, therefore, may be averaged to obtain the reciprocal of that price which, if maintained throughout the season, would result in the same consumption as occurred under the varying prices actually existing.

The average price just described is the harmonic mean of monthly prices. In using an average, it is always desirable to consider what type of average best describes the important characteristics of the series. In the present instance the average is intended to give a single price which, maintained throughout the season, would be substantially equivalent to the varying price actually observed. The simple arithmetic mean satisfies the condition that the amount paid for the total quantity at that price would equal the total amount paid at the actual prices, assuming an equal amount sold at each price. The harmonic mean satisfies the condition that the amount taken at that price would equal the amount taken at the varying prices actually observed. Obviously the condition satisfied by the harmonic mean is the important requirement for present purposes.



back to 1905 or earlier, and one dealer had records extending back to 1890.<sup>5</sup>

These four dealers made available their original records of car-lot sales, giving the price received for the cars, the freight paid, and, either directly or by calculation, the amount received after the deduction of freight from Minneapolis or St. Paul to destination.

The data obtained began with September, 1899, altho it was later found that nothing prior to September, 1902, could be used in the study, owing to defects in earlier production statistics. Significant prices for Minnesota potatoes could be obtained only for the nine months, September to May, of each year. Very few Minnesota potatoes are shipped in the three summer months.

For the seven seasons, 1899-1900 to 1905-6, records were taken for each business day on which sales were made. Wherever possible, records were taken for three separate car-lot sales on each day. Care was taken to exclude from these records all cars which appeared to contain seed stock, to be in bad condition, or to have any other characteristic which prevented them from being representative sales. Study of actual sales on any day will usually show a large proportion of the sales made at prices which are considerably above or below the going price for average quality table potatoes. The daily prices thus obtained were averaged to obtain weekly, monthly, and annual average prices.

Beginning with September, 1905, records of sales were obtained from three dealers instead of but one, and it appeared sufficient to take records of only three sales each week from each dealer. For simplicity in doing the work, the three records taken each week were for car-lot sales made on the same day, except where three representative sales could not be obtained on the same day. The records thus obtained gave an average price for each month based on either 36 or 45 representative car-lot sales, the exact number depending on the number of weeks in the month. Beginning with February, 1912, similar records were obtained from the fourth dealer, so that for the remainder of the period the average price for each month was based on either 48 or 60 representative car-lot sales.

Beginning with September, 1917, the prices reported by the Bureau of Agricultural Economics, then called the Bureau of Markets, were used. For the four years, 1917-18 to 1920-21, the monthly averages were based on the prices on Tuesday of each week as reported by

<sup>5</sup> The writer wishes to acknowledge his obligation to J. R. Beggs and Co., the E. C. Best Co., the J. C. Famechon Co., and the D. E. Ryan Co., for making their records available. He is under obligation for assistance given by numerous individuals connected with these firms, and especially for the aid given by numerous individuals connected with these firms, -dmar Agricultural Economics.

the Bureau. For the year 1921-22 the monthly averages were based on the prices of all the business days of each month.

The accuracy of the prices obtained from the dealers for the period after September, 1905, was increased by calculating the average for each dealer for each week, plotting the resulting price curves, and noting all cases where the price of one dealer differed materially from the prices of the others. In every case of discrepancy of this sort the original sales records were examined again without reference to the first set of sales taken off, special effort was made to choose a representative set of sales, and a new price for that week was obtained. In most cases this process resulted in showing that one or two of the sales first taken off for that dealer were not representative.

The weekly prices thus obtained from the separate dealers corresponded very well throughout each year except one, 1910-11. The weekly prices obtained from the separate dealers during 1910-11 showed so little consistency that it seemed better to have more data. Accordingly, a complete new set of prices was obtained for each dealer, for the entire season, taking prices for Fridays instead of for Tuesdays. This second set of prices showed more consistency than the first set, owing to the fact that more sales were made on Fridays than on Tuesdays and it was easier to pick representative sales. Even then there was not as close a correspondence between the weekly prices of the various dealers as existed in the other years. However, when the weekly prices of all the dealers were averaged together in each set separately, the two sets showed substantially the same price movements. Apparently the errors which caused the discrepancies between the prices for individual dealers were chance errors and tended to offset each other when averaged together. This being the case, it was thought best to average together both sets of records obtained for the year. As a result, the prices for 1910-11 are based on twice as many sales as the prices for 1909-10, for example.

In order to determine the accuracy of the methods used, two checks were made. It will be remembered that for the seven years, 1899-1900 to 1905-06, records of sales of one dealer on every business day were taken. Next an entirely independent set of records was taken from the same dealer, using the method adopted for later years, namely, that of taking sales for only one day of each week. The results, shown in Table II, indicate the substantial accuracy of annual averages based on prices of one day each week. Despite the fact that the prices were obtained from but one dealer, the two methods show no discrepancy greater than one cent, and that discrepancy appears in only three out of seven years.

TABLE II  
AVERAGE PRICES OBTAINED FROM RECORDS OF DEALER A

Method	Average price for year, per bushel						
	1899- 1900	1900- 1901	1901- 1902	1902- 1903	1903- 1904	1904- 1905	1905- 1906
Daily records.....	Cents 37	Cents 35	Cents 74	Cents 35	Cents 72	Cents 31	Cents 48
Records of one day a week.....	36	35	73	36	72	31	48

The second check made was to determine the probable accuracy of the prices obtained for the first six years from a single dealer as compared with the prices obtained during the remaining years from records of several dealers. For this purpose, records were taken of the daily sales of Dealer A during 1905-06 precisely as during the preceding years, and compared with the results obtained by the method followed during the remainder of the period. Table III shows the close similarity between the results of the two methods as applied to the same year.

TABLE III  
COMPARISON OF THE MONTHLY AND ANNUAL AVERAGE PRICES PER BUSHEL OBTAINED  
IN DIFFERENT WAYS FOR THE YEAR 1905-1906

	Daily records	Records from one day each week			
	Dealer A	Dealer A	Dealer B	Dealer C	Average
	Cents	Cents	Cents	Cents	Cents
September .....	34	35	36	37	36
October .....	46	45	43	36	41
November .....	55	56	54	48	53
December .....	49	49	50	56	52
January .....	52	51	52	46	50
February .....	47	47	46	46	46
March .....	40	40	42	42	41
April .....	52	53	56	50	53
May .....	50	52	55	50	52
Average .....	48	48	48	46	47

Table III shows also the degree of similarity between the results obtained for the several dealers as regards both monthly and annual average prices. It indicates that altho a satisfactory annual average is obtained from a single dealer, taking records of one day each week, the monthly averages so obtained are subject to considerable error. The accuracy of the annual averages obtained from records of one day each week is indicated more completely in Table IV. Only in two years—years of violent price fluctuations—do the annual averages for individual dealers vary more than one or two cents from the average for the group.

At least part of this difference represents an actual difference in the price obtained for the potatoes sold. For example, the potatoes raised in southeastern Minnesota in 1921 were of distinctly poorer quality than

those raised in the Red River Valley region. A dealer handling potatoes chiefly from the southeastern Minnesota region would necessarily obtain a lower price on the average during the 1921-22 season than a dealer handling chiefly Red River Valley potatoes. Similar situations are not uncommon.

TABLE IV  
ANNUAL AVERAGE PRICES PER BUSHEL BY DEALERS, 1905-1906 TO 1916-1917

Year	Dealer A	Dealer B	Dealer C	Dealer D	Average	Greatest deviation from average
	Cents	Cents	Cents	Cents	Cents	Cents
1905-06 ...	48	48	46	..	47	1
1906-07 ...	44	43	41	..	43	2
1907-08 ...	55	54	53	..	54	1
1908-09 ...	71	72	72	..	72	1
1909-10 ...	38	35	36	..	36	2
1910-11 ...	57	50	60	..	55	5
1911-12 ...	88	90	87	*	88	2
1912-13 ...	39	39	38	40	39	1
1913-14 ...	59	61	63	61	61	2
1914-15 ...	42	42	†	40	42	2
1915-16 ...	67	70	68	71	69	2
1916-17 ...	153‡	158‡	155‡	158‡	155‡	3

\* Records for four months only were obtained from this dealer for 1911-12.

† Satisfactory prices were unobtainable for certain months. Other months were included in the average for all dealers, however.

‡ The averages are for eight months. So few sales were made in May that representative prices could be obtained from only two dealers, hence the necessity of excluding prices for May in this comparison.

It is commonly supposed that some dealers are able to get better prices, on the average, than other dealers, because of more careful study of the market and favorable trade connections. This is undoubtedly the case to some extent, but the data in Table IV can not be taken as proof of the fact because of the inadequacy of the data. The annual average for each dealer is made up of 38 groups of 3 sales each, the groups being distributed uniformly throughout the season. This is not a large number in view of the difficulty of getting representative sales for each group and of the possibility that all the sales in a single group are occasionally made under abnormal conditions existing for a short time.

Altho the accuracy of the annual averages for the separate dealers can not be trusted to the extent of justifying their use in comparing the ability of different dealers to sell to good advantage, the evidence shown in Table IV indicates their substantial accuracy. The average actual error in the prices for individual dealers is probably not far from one cent. This being the case, the final average price obtained by averaging the prices for all dealers is approximately accurate.

The monthly and annual average prices obtained by the methods described in this section are given in Table VIII at the end of the bulletin. The table gives two figures for each annual average. The



first is the ordinary arithmetic mean of the monthly prices (properly weighted); the second is the harmonic mean. The reason for preferring the harmonic mean has already been explained (p. 10).

### FUNDAMENTAL FACTORS WHICH DETERMINE PRICE

The important fundamental factors determining the price of potatoes in Minneapolis and St. Paul are:

1. Production of potatoes in the entire United States.
2. Loss in storage.
3. Changes in the general price level.
4. A steady and uniform annual increase in the demand for potatoes.
5. Failure of the production of potatoes to increase as rapidly as the demand is increasing.

Each of these factors requires further consideration.

#### FACTOR NO. 1.—PRODUCTION OF POTATOES IN THE ENTIRE UNITED STATES

It is obvious that when the production of potatoes in the United States is large, prices must be low, or the potatoes can not be sold. If production were the only factor affecting price, it would be easy to determine the relation between the two. A chart could be made from the statistics of a number of years showing the price which actually accompanied the production which was obtained in each of the years. These points would be found to lie along a smooth curve which could be drawn through them and used as a basis for determining the price which would accompany a crop of any size, within the limits of variation actually observed.

Since several factors in addition to production have an influence on price, the relation between production and price can be determined in practice only by adjusting the actual figures in such a way as to correct for the other factors involved. Figure 2 shows the actual figures for the years 1902-20 with these adjustments made. The factors for whose effect correction is made are: (a) changes in general price level, (b) increase in the demand for potatoes, and (c) failure of the production to increase as rapidly as the demand. Lack of statistics on losses in storage makes it impossible to correct for that important factor. In this chart each dot represents the adjusted price, measured on the vertical scale, which was found to result from the corresponding adjusted production, measured on the horizontal scale.

If correction could be made for losses in storage and if the statistics used were complete and perfectly accurate, the dots in Figure 2

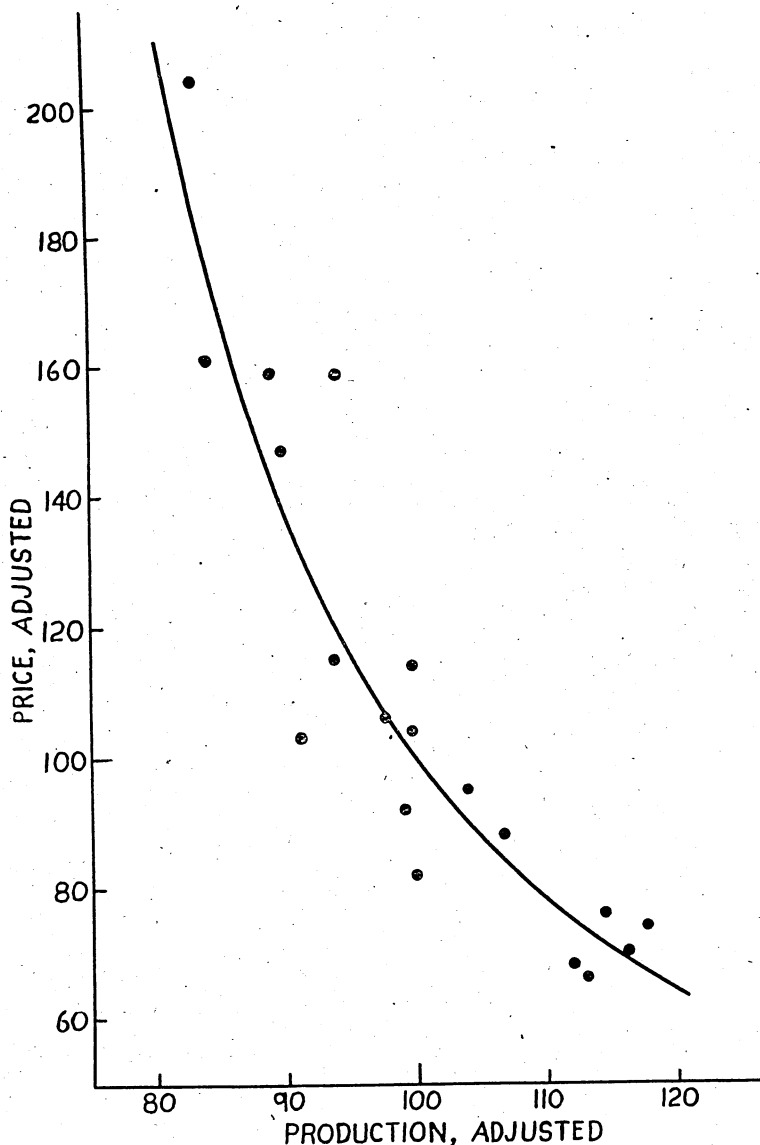


Fig. 2. Relation Between Price and Production

When price and production are adjusted to remove, as far as possible, the effect of other factors influencing the price, the relation between price and production becomes clear. The curve may be looked upon as a demand curve. Its equation is  $y = \frac{1}{-174.4 + 2.749x}$

would all be very close to a curved line similar to the line shown. In spite of the scattering of the points it is possible by the use of proper mathematical methods<sup>6</sup> to calculate quite accurately the position of the line which the points would approach if the corrections

<sup>6</sup> The method of least squares.

were more nearly complete and accurate. This is the curved line shown in the chart.

The curved line in Figure 2 may be looked upon as the demand curve for potatoes in the United States, provided certain facts are borne in mind. It shows the amount of potatoes (adjusted) which will be "taken" at each of the various prices (also adjusted) within the range of the curve. By the term "amount of potatoes taken" must be understood not only the amount bought by "consumers" but the amount which will be kept by farmers for their own use and for feeding, and even amounts left in the ground in case the price obtainable does not pay the costs of harvesting. The amounts shown also include the average quantities lost from rotting in storage and in other ways. This differs from the more common interpretation of the demand curve, which attempts to show the "amounts which will be bought" at each of a variety of prices.<sup>7</sup>

The figures for production of potatoes in the United States which are usually accepted are those published by the United States Department of Agriculture. These figures are unsatisfactory because of the tendency for a cumulative error to develop in the estimates of acreage, which are used in arriving at the estimate of total production. For example, the correction of such an error in the winter of 1921-22 prevented the estimate of production in 1921 from being comparable with the estimate for previous years and caused much difficulty in the potato trade. It has been found more satisfactory in the present study to assume that acreage increases at a perfectly uniform rate, and to neglect the annual estimates of changes in acreage. The adjusted production data shown in Figure 2 are based on the published estimates of yield per acre applied to an acreage obtained by assuming a uniform annual increase. Likewise, in the formula for estimating price, which appears farther on in this bulletin, consideration is given to the published estimates of yield per acre but not to the published estimates of acreage.

<sup>7</sup> The concept of the demand curve as describing the amounts taken or kept by everybody in the market, potential sellers as well as potential buyers, seems more useful than the usual concept. There is excellent support for the concept suggested. Davenport (*Economics of Enterprise*, p. 51) suggests it when he says: "It is \* \* \* evident that if we decide to regard the money side of the situation as demand for hats, and the hat side of the situation, not as demand for money, but only as supply of hats, we must recognize the holders of hats as themselves having demands for hats."

Wicksteed is strong in his championship of the concept. Taussig (*Quarterly Journal of Economics*, May, 1921, p. 396) quotes him as follows: "What about the 'supply curve' that usually figures as a determinant of price coördinate with the demand curve? I say it boldly and baldly: There is no such thing. What usually figures as such is merely a disguised and therefore unrecognized portion of the 'demand curve.' Diagrams of intersecting curves (and corresponding tables) of demand prices and supply prices are therefore profoundly misleading. They concentrate the attention of the student upon distinctions which have no theoretical relevancy; they coördinate as two determinants what are really only two arbitrarily and irrelevantly separated portions of one." (*Report of British Association for Advancement of Science*, 1913, p. 568.)

A change in the basis for estimating yield per acre somewhat similar to the recent changes in the basis for estimating acreage gives yield figures since 1902 which are not comparable with the yield figures for earlier years. It is this discrepancy which prevented the inclusion of years prior to 1902 in the statistical study on which this bulletin is based. However, no evidence has been discovered to indicate similar discrepancies in the yield figures for more recent years.

The United States Department of Agriculture is rapidly improving the accuracy of its system of crop estimating. Blame for existing inaccuracy is to be attributed not to incompetency but to lack of sufficient means to accomplish an exceedingly difficult task. It is to be hoped that the methods of crop estimating will soon be sufficiently improved to make the estimates of changes in acreage reliable enough for use in estimating price.

#### FACTOR NO. 2.—LOSS IN STORAGE

A moment's thought leads to the conclusion that loss in storage must necessarily be an important factor affecting price.<sup>8</sup> A loss of 5 per cent of the crop from rot in storage should have approximately, if not precisely, the same effect on price as a decrease of 5 per cent in production.

However, the statement that loss in storage constitutes an important factor affecting price is based upon statistical evidence as well as upon common sense. Mention has already been made of the fact that no accurate statistics are available for losses in storage. However, the heaviest losses in storage result from late blight rot, which is fairly closely correlated with the prevalence of late blight in the field.

Since 1917, the Plant Disease Survey of the United States Department of Agriculture has published estimates of the reduction in yield owing to late blight of potatoes, *Phytophthora infestans*. Since 1919 it has published information also on the prevalence and severity of late blight rot in carload shipments of potatoes inspected by the survey. Estimates of reduction in yield have not been published for earlier years, but the Plant Disease Survey has on record reports from the various states regarding the prevalence of late blight for each year since 1903.<sup>9</sup> Despite the inadequacy of these early reports, it is possible to determine from them whether late blight was light, moderate, or severe in each of the years covered. Column 2 of Table V gives this information.

<sup>8</sup> Throughout the discussion, the term "loss in storage" is used to cover all losses from spoilage, whether occurring in storage, in transit, or even in the bins of retailers or consumers.

<sup>9</sup> The writer is under obligation to Dr. Stakman and Dr. Leach of this station and to the Plant Disease Survey for abstracts of this material.



Figure 2, it will be remembered, shows the adjusted price resulting from the adjusted production of each year, 1902 to 1920. Heavy losses in storage should have the same effect as a decrease in production. Consequently, if we assume that loss in storage is the sole cause of the scattering of the points about the curve, the horizontal distance of each point from the curve should be a measure of the amount of loss in storage. These indications of the amount of loss in storage are shown in column 3 of Table V as light, moderate, or heavy, under the heading "Indicated loss in storage." In connection with the further use of this term, the reader must be careful to bear in mind that the figures for indicated loss in storage are obtained on the assumption that the scattering of the points about the demand curve shown in the chart is caused solely by loss in storage. This is obviously not true, since there is necessarily a certain amount of error in all the statistics used, which accounts for part of the scattering.

TABLE V  
CORRELATION OF PREVALENCE OF LATE BLIGHT WITH "INDICATED LOSS IN STORAGE"

1 Year	2 Field loss from late blight			3 Deviation of indicated loss in storage from average loss (per cent of normal production)			4 Cor- rela- tion
	Light	Moderate	Severe	Light	Moderate	Severe	
1902-03 .....				-7.7			
1903-04 .....			x			+2.6	+
1904-05 .....		x			+1.0		+
1905-06 .....			x	-7.5			-
1906-07 .....	x				+1.7		
1907-08 .....	x					+4.2	
1908-09 .....	x				+1.6		
1909-10 .....	x			-4.7			+
1910-11 .....	x				0.0		
1911-12 .....	x				-1.8		
1912-13 .....		x				+5.3	
1913-14 .....	x				-1.3		
1914-15 .....		x				+3.0	
1915-16 .....			x		+1.2		
1916-17 .....	x				+2.0		
1917-18 .....		x			+2.3		+
1918-19 .....	x			-4.0			+
1919-20 .....			x			+7.5	+
1920-21 .....			x	-4.8			-

Column 4 of Table V shows the correlation between the extent of late blight in the fields and the indicated loss in storage, a plus sign indicating definite correspondence, a minus sign indicating definite lack of correspondence, and no sign being shown where the correspondence or lack of correspondence is not definite. For example, when a moderate indicated loss in storage is associated with either light or severe occurrences of late blight, or vice versa, there is no definite indication of either correspondence or lack of correspondence because of the

rough character of the classifications. The nature of the data on prevalence of late blight renders more refined calculation impossible.

Table V shows that out of nine years for which the facts are definite enough to form a basis for conclusions there were six in which the indicated loss in storage corresponded with the prevalence of late blight and three years in which the two failed to correspond. This is probably as close a correspondence as could be expected, even on the assumption that the "indicated loss in storage" is identical with the actual loss in storage. Considerable loss in storage is due to black-leg rot, *Fusarium*, and the potato leak, in addition to late blight rot. Furthermore, losses in storage from late blight rot are only roughly proportional to the prevalence of late blight. Some indication of this is given in figures published by the Plant Disease Survey. The estimated reduction in yield due to late blight was almost twice as great in 1920 as in 1919, the figures being 4.7 per cent for 1919 and 7.9 per cent for 1920. However, losses from late blight rot in storage appear to have been much more severe in 1919 than in 1920. The Plant Disease Survey reports that in 1919, 5959 cars were inspected, of which 1000 had late blight rot present, with an average percentage of rot, when present, 8.3. In 1920, 5140 cars were inspected, of which 651 had late blight rot present, with an average percentage of rot, when present, of 5.6.

In the presence of so many disturbing factors, close correspondence between prevalence of late blight and total losses in storage from all causes is not to be expected. The existence of such correlation as is found between prevalence of late blight and indicated loss in storage may be taken as evidence that the indicated loss in storage is close to the actual loss in storage, in other words, that loss in storage is the only important factor not allowed for in the adjustment of production and price for Figure 2.

More conclusive evidence as to whether loss in storage is the only important factor not corrected for may be obtained by judging whether actual variations of loss in storage might reasonably be almost as great as the variations of indicated loss in storage. The average of the three years of least indicated loss in storage is less than the average loss by 6.3 per cent of the normal production. The average of the three years of greatest indicated loss in storage is greater than the average loss by 5.7 per cent of the normal production. This represents a range between the three years of lowest indicated loss and the three years of highest indicated loss of 12 per cent of the normal production.

It is difficult to get any figures on actual loss in storage, but estimates have been obtained from a number of growers and dealers and others interested in such losses. These estimates place the average

loss in storage for the entire United States at from 10 to 15 per cent of the crop. The variation to be frequently expected in this loss is estimated at from 3.5 to 5 per cent above and below the average. According to these estimates, the range to be expected is from 7 to 10 per cent. If these estimates are approximately correct, there remains only about half of the indicated loss in storage to be explained by inaccuracies in the data and other factors.

The figures for "indicated loss in storage," it will be remembered, are based on the discrepancy between the actual price and the estimated price, on the assumption that loss in storage explains all of that discrepancy. However, it is necessary to assume considerable inaccuracy in the data used. The production estimates used included no correction for changes in acreage other than a uniform annual increase; the yield figures are subject to a certain degree of error, the amount of which can not be determined; the wholesale price index number does not give an entirely accurate measure of the changes in the general price level; the annual increase in the demand for potatoes, and the extent to which production is lagging behind this increase, may have been measured somewhat inaccurately; even the figures on the price of potatoes are subject to some error. All of these inaccuracies result in increasing the variation in the indicated loss in storage. This may easily account for the variation which is not accounted for by variation in actual loss in storage.

Any other factor affecting price would have an effect similar to that of loss in storage in increasing the variation in indicated loss in storage. With 7 to 10 per cent of this variation accounted for by actual loss in storage and most of the remaining variation accounted for by inaccuracies in the data used, there is no room for supposing that there are any important factors affecting price which have not been considered. Any factors in addition to the five important ones herein discussed must have a very minor effect on the price of potatoes.

The demonstration of the importance of loss in storage as a factor affecting price indicates the necessity for compilation of statistics on these losses. Collection of such figures is of even greater importance than improvement in the accuracy of the estimates of acreage and yield. Investigations should also be made to devise methods of forecasting loss in storage. Losses from such causes as late blight rot and *Fusarium*, which are dependent upon field infection, should offer opportunity for fairly accurate prediction before the crop is harvested. Statistical studies of the effect of weather conditions upon infection and development of rots should yield valuable results in making possible the forecasting of losses from weather conditions in the late summer and fall.

## FACTOR NO. 3.—CHANGES IN THE GENERAL PRICE LEVEL

Changes in the general price level in the United States are best measured by the Bureau of Labor Statistics "all commodities" index number of wholesale prices. Changes in the general price level are not really causes of changes in the price of potatoes; both are the results of other causes. However, too little is known as yet regarding the causes of changes in the general price level to make it profitable to consider directly the effect of these causes on the price of potatoes. It is much more satisfactory to consider the relation between their effect on the price of potatoes and their effect on the general price level.

For convenience, the changes in the general price level may be divided into three classes: (1) General long-time tendencies; (2) large and violent fluctuations covering a relatively short period of years (the recent war-time inflation); and (3) the moderate fluctuations which recur with each cycle of business prosperity and depression. The price of potatoes has shown a general trend somewhat different from that of the general price level, owing to the failure of the production of potatoes to increase as rapidly as the demand, a factor to be discussed in detail later. Aside from this difference in general trend, the price of potatoes has been found to be subject apparently to the same influences as the general price level and to be affected by them in the same degree. Correction being made for those factors which affect the price of potatoes, but do not appreciably affect the general price level, the price of potatoes appears to move in exact unison with the general price level.<sup>10</sup>

<sup>10</sup> This statement is based, (1) on the fact that by estimating price on this assumption, as accurate estimates are obtained for the recent years of violent price fluctuation as for earlier years; (2) on negative results obtained in a multiple correlation study using yield per acre, price corrected for changes in the general price level, and the Harvard Price Index of Business Cycles; and, (3) on correlations of month-to-month changes in the price of potatoes with month-to-month changes in "all commodities," "food," and "farm products" index numbers of the Bureau of Labor Statistics. The latter correlations give the following results:

Index number	Coefficients of correlation of month-to-month changes, price preceding (—) and following (+) the index number							
	1900-1915				1915-1921			
	—2 mo.	—1 mo.	0 mo.	+1 mo.	—2 mo.	—1 mo.	0 mo.	+1 mo.
All com- modities ..	+0.09	+0.31	+0.21	+0.04	.....	.....	+0.51	.....
Food .....	—0.01	+0.32	+0.19	.....	.....	+0.34	+0.65	.....
Farm products ..	+0.14	+0.38	+0.21	+0.01	.....	+0.20	+0.38	.....

Except for the small coefficients, the probable errors are all relatively very small.



#### FACTOR NO. 4.—A STEADY AND UNIFORM ANNUAL INCREASE IN THE DEMAND FOR POTATOES

It is unnecessary to determine the amount of the annual increase in demand since the effect of the increase is taken care of in an indirect manner by the method used for expressing changes in production and by the determination of the effect of failure of production to increase as rapidly as demand is increasing. The fact that the demand for potatoes in the United States is increasing is obvious and requires no discussion here. The conclusion that the increase is by uniform annual amounts is based on the fact that the general trend of production is satisfactorily indicated by a straight line and the further fact that the measure of the failure of production to increase as rapidly as the demand is increasing is also a straight line. It follows that, within the limits of accuracy fixed by the character of the data, demand is shown to be increasing by uniform annual amounts.

#### FACTOR NO. 5.—FAILURE OF THE PRODUCTION OF POTATOES TO INCREASE AS RAPIDLY AS THE DEMAND IS INCREASING

The conclusion that the production of potatoes is increasing less rapidly than the demand follows from the fact that the price of potatoes is rising relative to the general price level. This may be seen from a chart showing the changes in the price of potatoes and also the changes in the general price level. It appears more clearly on a chart showing the relative price of potatoes, calculated by dividing the price of potatoes for each year by the corresponding value of the index number of wholesale prices.

The steady increase in the price of potatoes relative to the general price level is practically identical with the increase which has taken

The regression coefficients are also important:

Index number	Regression coefficients of price on index number for month-to-month changes, price preceding (—) and following (+) the index number							
	1900-1915				1915-1921			
	—2 mo.	—1 mo.	0 mo.	—1 mo.	—2 mo.	—1 mo.	0 mo.	—1 mo.
All com- modities ..	+0.79	+0.89	+1.67	+0.12	.....	.....	+1.81	.....
Food .....	—0.37	+1.55	+0.82	.....	.....	+0.90	+1.71	.....
Farm products ..	+0.48	+2.91	+0.70	+0.04	.....	+0.68	+1.10	.....

For the entire period, the price of potatoes in cents averaged from 0.61 to 0.64 of the value of the various index numbers. Accordingly, if the price of potatoes were affected in the same degree as the index number by the forces which caused changes in the index number, a change of one cent in the price of potatoes should accompany a change of 1.64 to 1.56 in the index number. The regression coefficients of price on the "all commodities" index number are fairly close to these figures for the lags which show the best correlations. The same is true for the regression of price on the "food" index number, but not for the regression of price on the "farm products" index number.

place in the price of almost all farm products. The chief cause appears to be the fact that it is no longer possible to increase production by settling new areas of highly productive farm land. Production may now be increased only by obtaining higher yields per acre or by making use of poorer land. Either method involves increased expense of production. Under these conditions, production can continue to increase only in response to higher prices for the product. The potato crop is only one of many farm products which are feeling the effect of the same forces.<sup>11</sup>

### FACTORS WHICH DO NOT INFLUENCE PRICE TO A MEASURABLE EXTENT

The following factors have been studied with care to determine whether they should be considered in estimating price. As far as can be determined from a study of the data for 19 years, these factors have no measurable effect on the price of potatoes in Minneapolis and St. Paul.

#### 1.—PRODUCTION IN THE STATES ADJACENT TO THE MARKET

The production of potatoes in the states nearest Minneapolis and St. Paul constitutes part of the total production of the United States. To that extent, the effect of variations in the production in these states is allowed for when total United States production is considered in estimating the price of potatoes. However, it is commonly thought that variations in production in the region surrounding Minneapolis and St. Paul have a much larger effect on price in those cities than similar variations in production in Maine or even in Michigan. It is natural to suppose that in any two years in which the production in the entire United States is normal, but in which the production in Minnesota

<sup>11</sup> This discussion contains an implication which will meet with objection from some economists. It assumes that if supply remained constant, an increase in price which exactly equaled the increase in the general price level would indicate a constant demand; in other words, that the taking of the same quantity of a commodity at a higher money price does not in this case signify an increased demand. This immediately raises the weighty objection that demand is to be measured in terms of quantities taken at particular money prices. An illustration of the force of this contention appears in the fact that changes in general price level occur only through changes in prices of individual commodities and must be studied as results of changes in the demand for those commodities.

On the other hand, there is much occasion for discussing demand in terms of purchasing power offered for various quantities of a commodity rather than in terms of the number of coins offered. The present case is such an instance. The confusion arises from the difficulty of adapting to the actual facts the terms and concepts worked out for a theoretical analysis under the assumptions of *caeteris paribus*.

It appears to the writer that where important changes in the purchasing power of money are involved, the concepts of the usual demand and supply analysis are more accurately followed by expressing demand in terms of purchasing power rather than in terms of money. However that may be, the term "demand" must continue to bear the burden of a multitude of meanings, to be much abused and be the source of many misunderstandings, until some general agreement fixes upon other terms to carry some of the various meanings now forced on one word. The usage here adopted has abundant support and, for the present at least, seems to offer the best means of expressing the facts.

varies widely, different prices in Minneapolis and St. Paul will result; that the effect of an excess production in Maine will not offset the effect of an equal deficiency of production in Minnesota, as far as the local price is concerned.

An investigation was made to determine the effect of variations in the production of Minnesota and Wisconsin taken together on the price of potatoes in Minneapolis and St. Paul. This investigation resulted in the discovery that variations in the production in Minnesota and Wisconsin had no measurable effect on the price of potatoes except to the extent that the production for the entire United States was affected.

Altho the fact is surprising, it is very readily explained when once recognized. The explanation will be somewhat clearer if the price situation as shown in Figure 1, p. 6, is borne in mind. Consider the extreme case of an excess production in Minnesota exactly equaled by a deficiency of production in Maine. In order to take care of the deficiency in the supply for New York City, for example, an unusual quantity is shipped in from New York and Pennsylvania. Large quantities of potatoes having been shipped east instead of west from New York and Pennsylvania, their place is taken by Michigan potatoes. But since Michigan potatoes are being shipped somewhat farther east than usual, Minnesota potatoes can be sold without competition in what is ordinarily Michigan territory. The result is that the Minnesota potatoes sell at practically the same price that would have been obtained if production in both Minnesota and Maine had been normal.

## 2.—IMPORTS AND EXPORTS

Altho the statistical study showed no measurable effect of imports and exports on price, the results should be interpreted as indicating that such effect as they have is very small. The effect may be assumed equal to that of a corresponding increase or decrease in the total United States production.

The effect of imports and exports on the price of potatoes has been studied both directly and indirectly. Direct study by a multiple correlation of price, net imports, and yield, gave negative results. Since imports and exports are likely to be very incompletely reported whenever there is no duty to be levied, an indirect method was tried also. This method was based on the fact that most of our imports come from Canada. Comparison of the relative size of the Canadian and United States production for each year offers a basis for judging the probable importance of imports from Canada. However, there was no evidence that variation in the Canadian crop had any measurable effect on the price of potatoes in Minneapolis and St. Paul.

The explanation of the failure to discover any relation between imports and exports and price is probably to be found in the relatively

small amounts imported and exported. The largest net importation in recent years was that of 1911-12, amounting to about 12,500,000 bushels. This was only 2.3 per cent of the United States production. The largest net exportation was in 1915-16 and amounted to about 3,800,000 bushels, or 0.9 per cent of the United States production. The heavy imports of 1911-12 came chiefly from the United Kingdom, imports from that source amounting to about 12,600,000 bushels. Since that year, quarantine regulations have excluded importations from all important sources except Canada and Bermuda. The largest net importations since 1911-12 were in 1919-20 and amounted to about 3,200,000 bushels, or 1.1 per cent of the United States production. Since these are extreme figures, it is apparent that imports and exports should not be expected to have any important effect on price.

### 3.—GENERAL BUSINESS CONDITIONS

The general price level is affected by business conditions, rising in periods of prosperity and falling in periods of business depression. However, the prices of some commodities are affected by these conditions much more than the general price level. Professor Persons has constructed a "Commodity Price Index of Business Cycles"<sup>12</sup> for which the fluctuations in each of the business cycles from 1900 to 1915 are about three times as great as those of the Bureau of Labor Statistics index number of "all commodities." Six of the ten commodities included in this index number are of agricultural origin, namely, hides, cotton sheetings, print cloths, worsted yarns, salt mess pork, and cottonseed oil. It appeared possible that potatoes might be similarly affected.

On the other hand, it appeared possible that potatoes, being a relatively cheap food, might be in greater demand during periods of business depression and less used in periods of business prosperity. If such were the case, potatoes would rise in price when most other commodities fall, and fall when most other commodities rise. It is certain that many commodities remain relatively unaffected by the business cycle or possibly even fall in price in periods of prosperity.

The possibilities suggested above made necessary a very careful study of the relation between the price of potatoes and the business cycle. The results obtained indicated that the influences connected with the business cycle affect the price of potatoes to the same degree that they affect the Bureau of Labor Statistics index number of "all commodities." This conclusion has been discussed already at greater length on page 22.

<sup>12</sup> Cf. *Review of Economic Statistics*, Nov. 1921.

# USE OF THE PRICE-ESTIMATING FORMULA

## ESTIMATION OF AVERAGE PRICE FOR THE SEASON

In order to estimate the price justified at any particular time by fundamental conditions of demand and supply, it is necessary first to estimate the average price for the season. Statistical study of the price of potatoes for the years 1902-3 to 1920-21 gives the following formula for estimating the average price in Minneapolis and St. Paul for the season September 1 to May 31:

$$\text{Price per bushel} = \frac{L \times T}{2.83Y - 174} \quad (1)$$

Market price is now ordinarily quoted in terms of hundredweights, for calculation of which the following formula is used instead of the one just given:

$$\text{Price per hundredweight} = \frac{L \times T}{1.70Y - 105} \quad (2)$$

Figures to be used in place of the letters in these formulas are obtained as follows:

L—Price level. The Bureau of Labor Statistics "all commodities" index number, 1913 = 100, must be used and an estimate made of its probable average for the nine months, September to May.

Y—Average yield per acre for the United States as a whole, from estimates of United States Department of Agriculture.

T—Values for this quantity for the years 1921-22 to 1924-25 are given in Table VI. The quantities shown are obtained on the assumption that the increase in demand for potatoes and the failure of production to increase as rapidly as demand continue as in the past. The values are shown for but a short period of years because they are better recalculated every few years.

TABLE VI  
VALUES OF T

Year	T
1921-22 .....	57.6
1922-23 .....	62.9
1923-24 .....	69.4
1924-25 .....	77.3

These formulas for estimating price take care of the effect of changes in production, of changes in the general price level, of the increase in demand for potatoes, and of the failure of production to increase as rapidly as demand is increasing. The only important factor not included is loss in storage. However, any one who is able to arrive at an estimate of the amount of loss in storage in which he

feels confidence can readily include its effect in the formula, as will be explained later. Most dealers, at least, will wish to make this correction.

It will be noted also that no account is taken of estimates of acreage. As a matter of fact, the formulas allow for the normal average annual increase, but for no other changes in acreage. It would be very easy to make allowance for changes in acreage if sufficiently accurate estimates of these changes could be obtained. The best estimates obtainable—those of the United States Department of Agriculture—have been subject to enough error to destroy entirely their value for use in preparing an estimate of price. The extent of the errors in the original estimates is indicated by the revisions which have been necessary, as shown in Figure 3. It is doubtful whether the year-to-year changes in even the revised figures are very reliable.

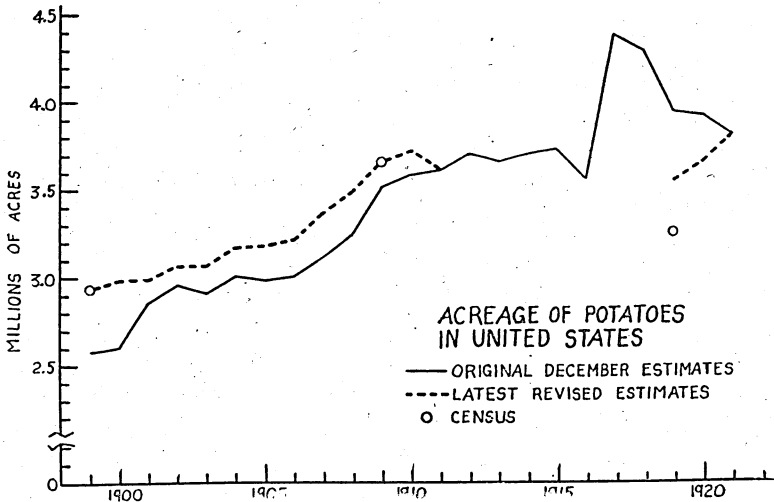


Fig. 3. Acreage of Potatoes in United States

The inaccuracy of the original estimates of acreage of potatoes shows why the acreage figures are of no value in estimating price. It is to be hoped that improved methods of crop estimating which are being adopted will soon result in estimates accurate enough to be of more value.

The Department of Agriculture is making great improvements in the accuracy of its crop estimates and it is possible that estimates of acreage are already sufficiently accurate to be of use in estimating price. Further study is necessary to find out whether this is the case. In the meantime, farmers and dealers should use their influence to bring about more adequate support for the important work of the crop-estimating service of the Department of Agriculture. No forecast of

prices can be more accurate than the figures on which it is based. Potato growers and potato dealers are in serious need, not only of more accurate estimates of acreage, but also of data on losses in storage and in transit and of early estimates of probable losses. It is also probable that the estimates of yield can be considerably improved, especially the early estimates based on condition reports. So far as is known, the Department of Agriculture has made no use of the method of predicting yields from weather conditions. Professor H. L. Moore has shown that estimates of the probable yield of cotton made from weather conditions are considerably more accurate than the Department's estimates based on reports of condition of the crop.<sup>13</sup> In view of the importance of its work, the crop reporting service of the Department of Agriculture deserves more liberal support.

Altho no estimates of probable loss in storage are now available and much work will probably be required before accurate estimates can be made, some idea of the probable loss can be obtained from reports on the prevalence of late blight and of *Fusarium*. Such reports are now published by the Plant Disease Survey of the United State Department of Agriculture. Any one who feels some confidence in his ability to estimate loss in storage can readily make use of such estimates in forecasting price.

In order to make allowance for loss in storage in the price-estimating formula, it is necessary merely to estimate the percentage of the crop over or under the average which will be lost in storage and correct the yield figure accordingly. The formula makes allowance for average loss in storage. If it is estimated, for example, that 5 per cent more of the crop will be lost in storage than is lost on the average, the yield figures used in the formula should be reduced 5 per cent from the estimated actual yield. Potatoes lost in storage have no more ultimate effect on price than if they had not been raised. Similarly, if it is estimated that 5 per cent less of the crop will be lost in storage than is lost on the average, the estimated yield should be increased 5 per cent for use in the formula. As has been said, the formula provides for average loss in storage.

The relative completeness with which the factors included in the formulas determine price is indicated in Figure 4. The average error is 9.5 per cent. In calculating the estimated price for each year, the yield figures of the Department of Agriculture are used directly, with no correction for probable loss in storage. As shown in Table V, p. 19, the discrepancy between the actual price and the estimated price in 1919, the largest discrepancy found, would be completely explained if 7.5 per cent more of the crop were lost in storage than is lost on

<sup>13</sup> Cf. H. L. Moore, *Forecasting the Yield and the Price of Cotton*.

the average. More than half of the discrepancy would be explained by a loss in storage only 4 per cent higher than the average.

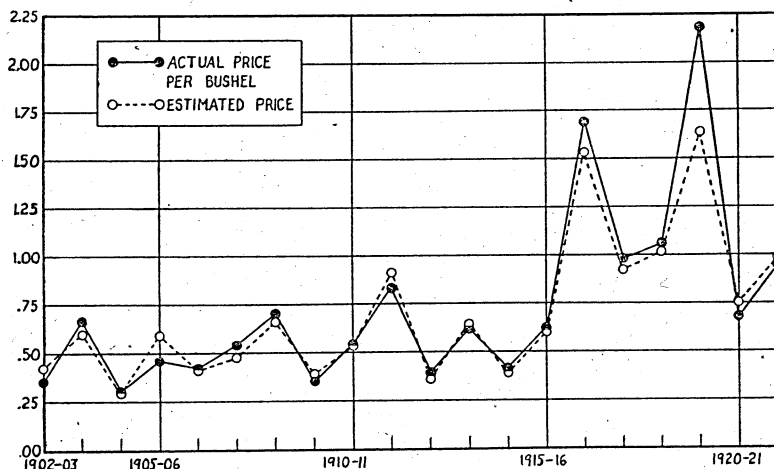


Fig. 4. Actual and Estimated Prices of Potatoes, 1902-03 to 1920-21

The estimated prices are obtained by means of the formulas presented in this bulletin. No correction was made for loss in storage in any of the estimates shown. The difference between the actual price and the estimated price should usually be judged in terms of percentage rather than in terms of actual amounts. The average error is 9.5 per cent.

The difference each year between the calculated price and the actual price is to be attributed to the following causes which are put into groups according to their relative importance:

1. Loss in storage. This factor is probably about as important as all the rest taken together.
2. (a) Errors in the actual price shown. The price estimate is for "average quality table potatoes." The average quality of the potatoes actually sold varies considerably from year to year, so that the price given is not an accurate indication of the price for "average quality table potatoes."
- (b) Changes in acreage which can not be considered because of the inaccuracy of the estimates.
- (c) Errors in the yield estimates.
- (d) Inaccuracy in the index number of general price level.
3. (a) Inaccuracy in the calculated values used in the formula. Every effort has been made to obtain accurate values, but it is probable that there is some error in the values obtained.
- (b) The factors found to have "no measurable effect" probably have some actual effect on price. There are probably other factors of minor importance which might have been



considered. If all these factors should act in the same direction in any year, the effect would be appreciable.

- (c) The actual price for the season is not always the price which should have resulted from the fundamental demand and supply conditions. A striking example appears in 1917-18. The price was so high during most of the season that a large amount of old crop potatoes was held over into the summer.

#### ESTIMATION OF AVERAGE PRICE FOR A MONTH

The price which fundamental conditions of demand and supply justify as an average for the season is not justified for each month of the season. Any one planning to hold or store potatoes until later in the season must receive a considerably higher price for the potatoes in the later months because of the expenses of storing and especially because of the shrinkage caused by rotting and by loss of weight from evaporation of moisture. In order to encourage the necessary storing of potatoes, the price must average considerably higher in the spring than in the fall. Costs of storing, including shrinkage, vary widely with different individuals and in different years. The most satisfactory way of determining the necessary seasonal variation in price is from the average variation in past years. Table VII and Figures 5 and 6 show the normal seasonal variation so determined.

TABLE VII  
SEASONAL VARIATION OF PRICE OF POTATOES IN MINNEAPOLIS AND ST. PAUL  
(16-YEAR AVERAGE, SEPTEMBER, 1899 TO MAY, 1915)

Month	Average price	Per cent of average for season
	Cents per Bu.	
September .....	49.4	96.2
October .....	45.5	88.6
November .....	47.1	91.7
December .....	47.9	93.2
January .....	51.5	100.3
February .....	54.8	106.6
March .....	55.6	108.3
April .....	57.1	111.1
May .....	56.4	109.9
Average (Harmonic mean).....	51.36	100.0

To calculate the price of potatoes which appears justified for any month, it is necessary merely to multiply the calculated average for the season by the appropriate percentage as given in column 3 of Table VII. This gives the market price to be expected, based on the figures on fundamental conditions which were used in calculating the average price for the season.

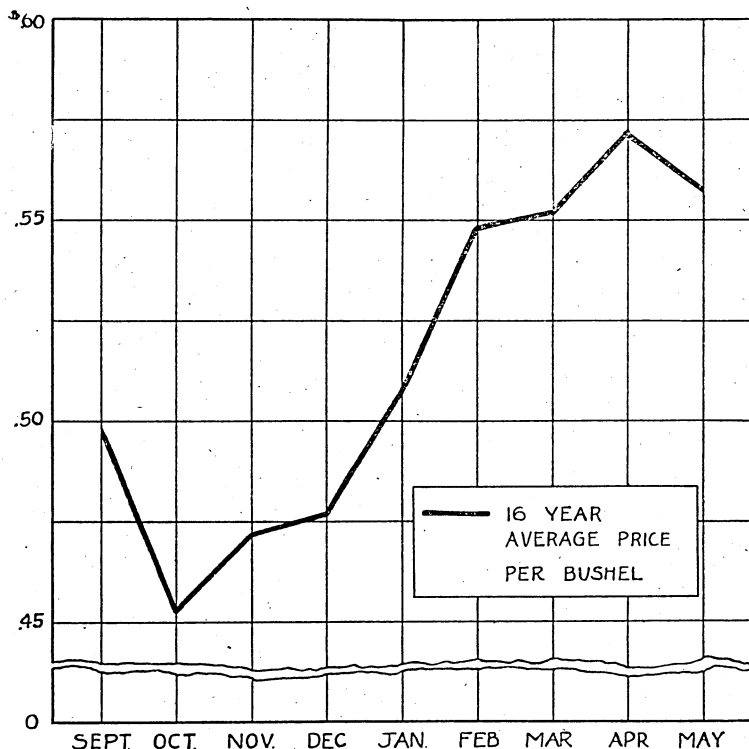


Fig. 5. Average Monthly Price of Potatoes for Sixteen Years

The price of potatoes in Minneapolis and St. Paul averages much higher in the spring than in the fall. This increase is necessary to compensate for shrinkage of potatoes in storage and for the cost of storage.

Figures 7a and 7b show the actual price of potatoes in Minneapolis and St. Paul monthly and also the price estimated by the methods which have been described.<sup>14</sup> The "first estimated price" is based on the average of the Bureau of Labor Statistics wholesale price index number for nine months, and therefore assumes that changes in the general price level for the entire season could be foreseen. The "second estimated price" bases the estimate for each month on the actual index number for that month. In ordinary years the two estimates give practically identical results, but under conditions such as existed during the war, it pays to try to look ahead.

A farmer who is considering holding his potatoes or a dealer who is considering buying for storage may use these monthly estimates in

<sup>14</sup> These charts were made on the basis of a formula calculated before the advantage of using the harmonic mean was discovered. As a result, the differences between the actual prices and the estimated prices here shown are not the same as appear in Figure 4. They also differ in that Figures 7a and 7b are "ratio charts"—a given vertical distance represents the same *percentage* difference in all parts of the chart. The conclusions to be drawn from these charts are not affected by the slight error in the formula used.

either of two ways. (a) He may calculate the price which appears to be justified at that particular time and base his action on the difference between the actual price and the estimated price. (b) He may calculate the estimated price for the month when he expects to sell and see if the difference between that estimated price and the actual price at the time will give him a profit over the cost of storage. Any one, whether farmer or dealer, who plans to use the estimates in either of these ways should read the last section of this bulletin, "Suggestions for a Selling Policy for Farmers." Most of the suggestions apply to dealers as well as to farmers.

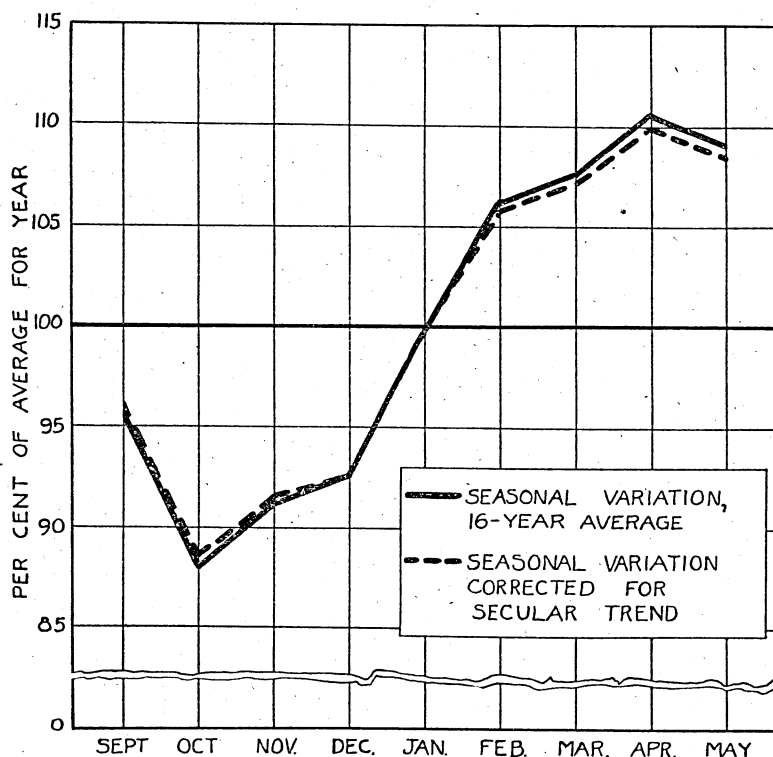
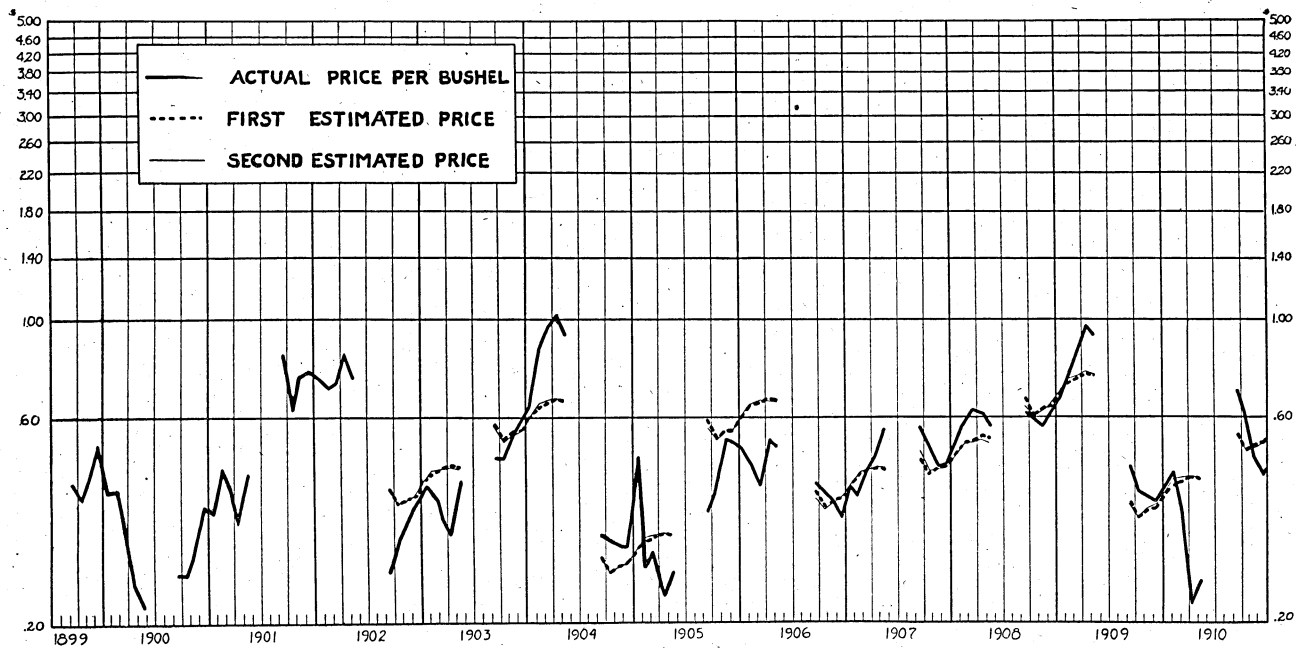


Fig. 6. Seasonal Variation in Price of Potatoes

Variation in price of potatoes during the season is shown here in terms of percentage, the average for the year.

#### CORRECTION OF ESTIMATE FOR QUALITY OF POTATOES AND FOR OTHER MARKETS

In using the formula for estimating price, it is necessary to keep in mind exactly what the estimate is. The formula uses estimates of fundamental demand and supply conditions to calculate a price which applies only to *average quality table potatoes on the wholesale market*



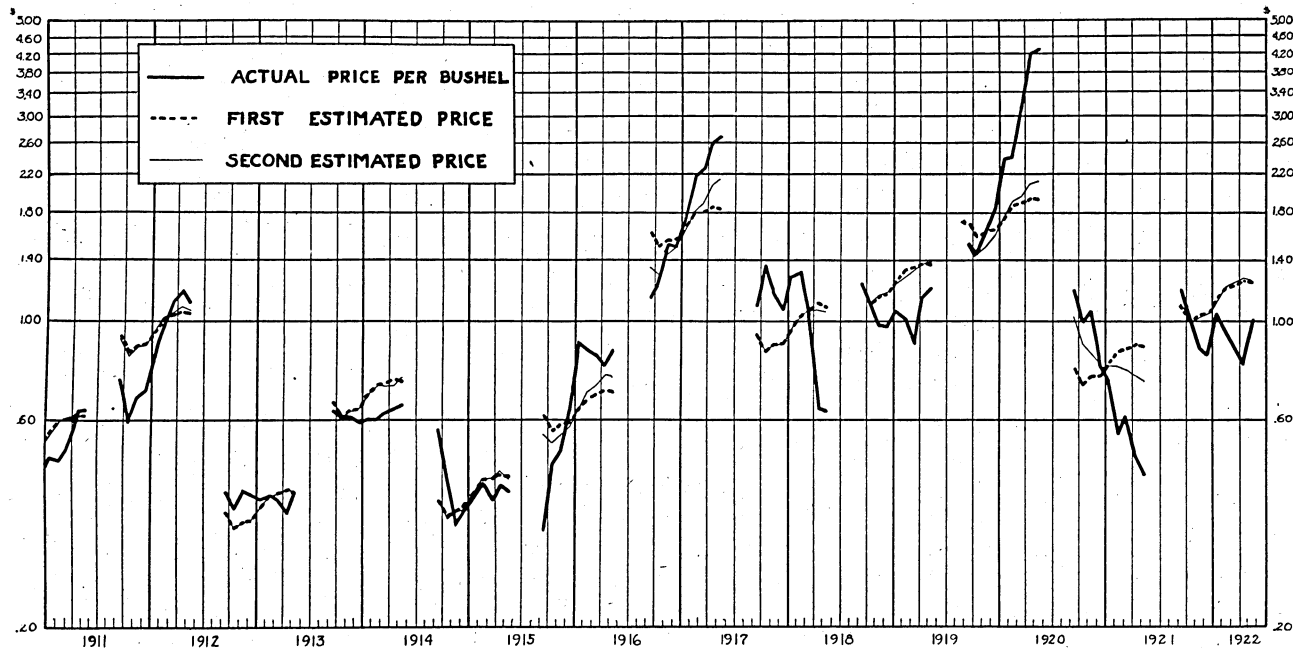


Fig. 7. Actual and Estimated Prices of Potatoes Monthly, 1899-1921

Monthly estimates of prices may be based either on the average price level for the season (first estimate) or on the price level for each month separately (second estimate). Usually the two are almost identical, but in 1920-21 it would have paid to look ahead in order to try to use the first estimate, which indicated that the actual price in the fall was much too high. This is a "ratio chart," that is, a given vertical distance represents the same percentage difference in all parts of the chart.

of Minneapolis and St. Paul. The result obtained may be corrected, however, to apply to distant markets and to various qualities of potatoes.

The necessity of correcting the estimated price of potatoes for differences in quality is obvious and needs little discussion. It should always be remembered that quality of potatoes is not to be judged by personal preferences but by market requirements, which are determined by the preferences of consumers. Uniformity and careful grading are important factors in obtaining good prices.

The price of potatoes in other localities may be estimated by calculating the price for Minneapolis and St. Paul and adding or subtracting the normal difference between the price in those cities and the price in the place for which the estimate is being made. Calculating the price in this way does not necessarily imply that the Twin City market fixes the price for other localities. The price-estimating formula takes into consideration only the fundamental forces which fix the price of potatoes over the entire United States. It measures the effect of these forces as applied specifically to the price in Minneapolis and St. Paul. As indicated in an earlier discussion,<sup>15</sup> prices in the various parts of the United States are closely related, the differences being the costs of moving the potatoes. Consequently, the forces which fix a certain price in Minneapolis and St. Paul will fix prices elsewhere which will differ by no more than the costs of moving the potatoes. In calculating these costs, however, it is frequently necessary to allow much more than freight charges. If several dealers must handle the potatoes, their margins must be added to the costs of moving the potatoes.

Farmers may correct the estimated prices to apply to their local market in exactly the same way that they correct the current quotations of actual prices. The only difference is that the actual prices are affected slightly by variations in the quality of the potatoes on the market, while the estimate always applies to potatoes of "average quality." In connection with both the estimated price and the quotations it should be remembered that they are based on the price of potatoes sold delivered to the buyer, less freight charges. In cold weather the dealer has additional expenses for heater service or else takes a chance of loss from freezing, and usually takes a larger margin to cover the added expense or risk.

Prices calculated by the formula may also be corrected to apply to Chicago, Kansas City, St. Louis, and even more distant markets by merely adding the proper market differential. Price so calculated may be considered quite accurate. It is highly desirable, however, that

<sup>15</sup> Cf. *supra* pp. 6 and 7.

similar formulas be worked out for all important markets. This would give an opportunity for checking results: for example, Twin City dealers could check the estimate given by the formula here presented with the estimate obtained by a Chicago formula, corrected for the market differential. Any well-trained statistician who is acquainted with the methods of correlation and curve-fitting can make the necessary calculations, provided he has a reliable set of monthly average prices beginning with the fall of 1902.<sup>16</sup>

### ESTIMATING THE PRICE OF SEED POTATOES

In estimating the price of potatoes intended for seed, the factors to be considered vary with the variety. Seed potatoes of the standard late crop varieties may be looked upon as table potatoes, perhaps of a higher quality than the average.

Triumphs, on the other hand, are affected by forces very different from those which determine the price of table stock. As raised in Minnesota, they usually sell for a large discount as table potatoes and consequently are sold for that purpose only when they can not be sold for seed. Ordinarily their price is determined by the supply and the demand for that particular variety of seed only. No special study has been made of the factors determining the price of this variety of potatoes.

Early Ohio, Irish Cobbler, and similar varieties, which, tho early, are satisfactory table potatoes for winter use, fall between the two classes of seed potatoes just discussed. Occasionally they are kept relatively high in price because of the demand for seed of each particular variety, but usually their price follows closely that of table potatoes. If they have to be sold as table potatoes late in the spring, they usually move only at a discount, owing to their poorer quality late in the season.

### APPLICATION OF THE FORMULA TO AN ACTUAL CASE

The price-estimating formula was worked out from data for the years 1902-03 to 1920-21, no data being available for 1921-22 at the time the work was begun. Application of the formula to estimating the price for 1921-22 gives an opportunity for illustrating its use and also for giving the formula a further test.

The yield of potatoes in 1921, as estimated by the United States Department of Agriculture, was 90.9 bushels per acre.<sup>17</sup> The average of the Bureau of Labor Statistics index number of wholesale prices

<sup>16</sup> The writer will be glad to answer questions regarding method and to furnish some of the necessary statistical data for the benefit of any competent person who has the necessary price data and wishes to calculate a price-estimating formula.

<sup>17</sup> Revised estimate.

was 142.<sup>18</sup> Placing these figures in the formula, together with the values obtained from Table VII, page 31, or from Table IX on the final page of this bulletin, we have:

$$\text{Price per cwt.} = \frac{142 \times 57.1}{1.70 \times 90.9 - 105} = \frac{8108}{155 - 105} = \frac{8108}{50} = 162 \text{ cts.}$$

The actual average (harmonic mean) price for the year was \$1.57 per hundredweight, giving a difference of 5 cents between the actual price and the estimated price.

The reason for using the harmonic mean has been explained earlier in this bulletin.<sup>19</sup> The harmonic mean is the *average quantity sold for a dollar* expressed in terms of price. It is calculated by dividing 1 by the average price for each month ( $\frac{1}{.50} = 2$ , etc.) adding the figures thus obtained for each month, dividing by the number of months, and dividing 1 by the result.

## SUGGESTIONS FOR A SELLING POLICY FOR FARMERS

The foregoing discussion has explained the operation of the price-determining forces and given a formula for calculating the price which is justified in any month of the season on the basis of apparent demand-and-supply conditions. Knowledge of these facts suggests the possibility that farmers and managers of coöperative associations may make additional profits by trying to sell at the right time. Some suggestions may be made along this line. Information presented in this bulletin may be used in either of two ways: (a) As a basis for a regular selling policy; or (b) as an aid to speculating on price changes.

a. An examination of Table VII and Figures 5 and 6 shows that on the average it is to be expected that the price of potatoes in April will be from 12 to 13 per cent higher than in October. This is the increase in Minneapolis and St. Paul. The percentage increase in the farm price is greater because while the market price is rising 12 per cent from 60 cents to 67 cents, the farm price may rise, for example, from 40 cents to 47 cents, which is an increase of more than 17 per cent.

Farmers (or dealers) who can make money on the average by storing potatoes, counting on such a rise in price, will do well to adopt a policy of always carrying their potatoes over until the late winter or spring. Farmers undertaking this policy should make it a practice to keep track of the quantity of potatoes put into storage each year and of the quantity which they finally sell. By doing this they may make sure that they have not underestimated the shrinkage to be counted on. Potatoes stored in a dry place lose a great deal of weight from evaporation of moisture, a factor frequently underestimated.

<sup>18</sup> New index number.

<sup>19</sup> Cf. *supra* p. 10.



A policy which may be adopted where average cost of storing does not justify holding until spring every year is that of storing in all years in which conditions are such as to promise very little shrinkage due to rot in storage. However, if conditions are similar over most of the United States, everybody will be inclined to store potatoes, with the result that prices will be little higher in the spring than in the fall.

A third possible policy, the safest of all, is to sell a certain percentage of the crop each month. Anyone who has read this bulletin with care will understand that any estimate of the price to be expected is subject to considerable error. Slight errors in yield figures are always to be expected; estimates of acreage harvested are inaccurate; loss in storage can not be predicted with any certainty. With these and other possible causes of errors in estimating prices, it is apparent that it is never possible to be sure what will happen. By distributing sales evenly throughout the season it is possible to play safe.

b. The farmer who wishes to try to judge the market, to hold his potatoes when prices appear to be lower than fundamental conditions justify, and to seize the opportunity of selling whenever prices seem as high as conditions justify or temporarily higher, should bear in mind that he is speculating. There is always too much uncertainty regarding the fundamental conditions of demand and supply to make possible any certainty as to what will happen to the price of potatoes. However, somebody must take the chance of possible loss on changes in the price of potatoes. There is no reason why farmers should not take the chance of loss (and the possibility of gain) provided they recognize that they are speculating and understand the chances they are taking.

The farmer who is planning to study the market and tries to make money by selling when it is most favorable should bear in mind two important facts:

1. The price at any time is the result of the best estimates of a large number of people as to what the price ought to be. There is never any chance of making money by "judging the market," except when the majority of these people are wrong. It frequently happens that the majority are wrong, owing to a misinterpretation of facts or to errors in what are supposed to be facts. Any one who can outguess the majority of those dealers and farmers who are trying to judge the market can make money at it. But remember, there is no money in speculation for the man who can not outguess the majority of those in the game.

2. It requires careful study to be able to judge the market well enough to avoid losses, and more to make profits. It is bad business to spend time in that way, as long as an equal amount of time spent in other ways will bring certain profits. Grading

carefully, shipping uniform lots, and raising a better quality of potatoes are usually sure means of increasing profits. Lack of care in shipping potatoes results in thousands of dollars of loss every year through rotting and freezing in transit.

TABLE VIII  
PRICE OF POTATOES PER BUSHEL IN MINNEAPOLIS AND ST. PAUL  
MONTHLY, 1899-1922, BY CROP YEARS—AVERAGE TABLE STOCK

	1899- 1900	1900- 1901	1901- 1902	1902- 1903	1903- 1904	1904- 1905	1905- 1906	1906- 1907
September .....	\$0.42	\$0.26	\$0.83	\$0.26	\$0.48	\$0.32	\$0.36	\$0.42
October .....	0.39	0.26	0.62	0.31	0.48	0.31	0.41	0.40
November .....	0.44	0.29	0.74	0.34	0.54	0.30	0.53	0.38
December .....	0.51	0.37	0.76	0.37	0.57	0.30	0.52	0.35
January .....	0.40	0.36	0.73	0.41	0.62	0.48	0.50	0.41
February .....	0.40	0.45	0.70	0.39	0.88	0.27	0.46	0.39
March .....	0.34	0.40	0.72	0.35	0.97	0.29	0.41	0.45
April .....	0.25	0.35	0.81	0.32	1.02	0.23	0.53	0.49
May .....	0.22	0.44	0.73	0.42	0.92	0.26	0.52	0.57
Annual Av.* .....	\$0.37	\$0.35	\$0.74	\$0.35	\$0.72	\$0.31	\$0.47	\$0.43
Harmonic mean .....	\$0.35	\$0.34	\$0.74	\$0.35	\$0.66	\$0.30	\$0.46	\$0.42

	1907- 1908	1908- 1909	1909- 1910	1910- 1911	1911- 1912	1912- 1913	1913- 1914	1914- 1915
September .....	\$0.57	\$0.61	\$0.46	\$0.70	\$0.74	\$0.41	\$0.63	\$0.57
October .....	0.51	0.59	0.40	0.59	0.58	0.37	0.61	0.43
November .....	0.46	0.57	0.39	0.48	0.68	0.42	0.61	0.34
December .....	0.46	0.61	0.38	0.44	0.70	0.40	0.59	0.37
January .....	0.52	0.66	0.41	0.49	0.87	0.39	0.60	0.39
February .....	0.58	0.77	0.45	0.48	0.97	0.40	0.50	0.42
March .....	0.62	0.85	0.35	0.52	1.12	0.39	0.62	0.39
April .....	0.61	0.97	0.22	0.63	1.19	0.36	0.53	0.42
May .....	0.57	0.91	0.25	0.63	1.11	0.41	0.65	0.41
Annual Av.* .....	\$0.54	\$0.72	\$0.36	\$0.55	\$0.88	\$0.39	\$0.61	\$0.42
Harmonic mean .....	\$0.54	\$0.70	\$0.35	\$0.54	\$0.83	\$0.39	\$0.61	\$0.41

	1915- 1916	1916- 1917	1917- 1918	1918- 1919	1919- 1920	1920- 1921	1921- 1922
September .....	\$0.33	\$1.12	\$1.07	\$1.26	\$1.54	\$1.19	\$1.10
October .....	0.47	1.22	1.38	1.10	1.46	0.99	1.02
November .....	0.51	1.51	1.18	0.97	1.59	1.06	0.88
December .....	0.64	1.48	1.07	0.96	1.83	0.78	0.83
January .....	0.90	1.67	1.19	1.06	2.39	0.72	1.04
February .....	0.86	2.16	1.21	1.01	2.43	0.55	0.95
March .....	0.83	2.25	1.04	0.89	3.17	0.61	0.86
April .....	0.79	2.56	0.64	1.15	4.21	0.49	0.79
May .....	0.86	2.78	0.63	1.21	4.28	0.44	0.99
Annual Av.* .....	\$0.69	\$1.78	\$1.05	\$1.07	\$2.52	\$0.75	\$0.95
Harmonic mean .....	\$0.62	\$1.69	\$0.98	\$1.06	\$2.18	\$0.68	\$0.94

\* Weighted average obtained by weighting monthly prices by the number of weeks included in each.

FORMULAS AND TABLES FOR ESTIMATING PRICE<sup>20</sup>

$$\text{Price per bushel} = \frac{L \times T}{2.83Y - 174} \quad (1)$$

$$\text{Price per hundredweight} = \frac{L \times T}{1.70Y - 105} \quad (2)$$

L = Bureau of Labor Statistics "all commodities" index number of wholesale prices, estimated average September to May.

Y = Estimated yield per acre for the United States.

T = Values differ for each year, as shown in Table IX.

The formulas give the average (harmonic mean) price for the season. Average prices for individual months may be obtained by multiplying by factors given in Table X.

TABLE IX  
VALUES OF T FOR USE IN FORMULA

Year	T
1921-22 .....	57.1
1922-23 .....	62.9
1923-24 .....	69.4
1924-25 .....	77.3

TABLE X  
SEASONAL VARIATION OF PRICE

Month	Per cent of average for season
September .....	96.2
October .....	88.6
November .....	91.7
December .....	93.2
January .....	100.3
February .....	106.6
March .....	108.3
April .....	111.1
May .....	109.9
Average (Harmonic mean).....	100.0

<sup>20</sup> The price obtained applies to potatoes of average table quality on the wholesale market of Minneapolis and St. Paul.

